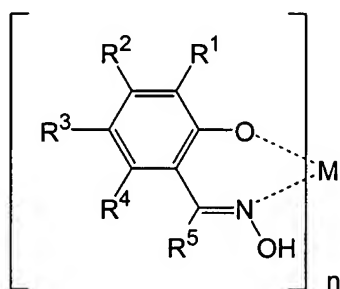


**WHAT IS CLAIMED IS:**

1. A dye stabilizer represented by the following formula:



(1)

wherein:

M is a metal ion;

n is 2 or 3;

R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, R<sup>4</sup> and R<sup>5</sup> are, independently, R<sub>f</sub>-A- (wherein R<sub>f</sub> and A are defined below), hydrogen, hydroxyl, halogen, nitro, cyano, alkyl, heteroalkyl, aryl, heteroaryl, alkylaryl, arylalkyl, alkyl-heteroaryl, heteroalkylaryl, aryl-heteroalkyl, heteroarylalkyl, alkoxy, aryloxy, benzoyl, acetyl, carbonyl, sulfonyl, amido, carbamoyl, sulfonamido, sulfamoyl or heterocyclyl, or any two of R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, R<sup>4</sup> or R<sup>5</sup> together may form a cycloalkyl or heterocyclic group, provided that at least one of R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, R<sup>4</sup> and R<sup>5</sup> is R<sub>f</sub>-A-;

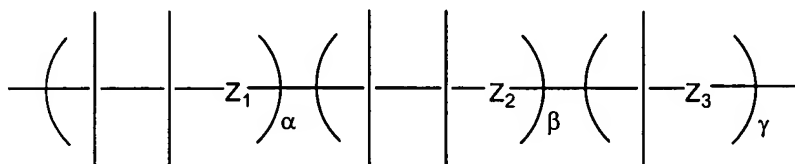
A in R<sub>f</sub>-A- is absent, oxygen or an alkylene chain; and

R<sub>f</sub> is a fluorinated alkyl or aryl or a low/medium molecular weight fluorinated polymeric or oligomeric moiety.

2. The dye stabilizer of Claim 1 wherein said metal ion is a divalent metal ion.
3. The dye stabilizer of Claim 2 wherein said metal ion is Co, Cu, Fe, Mn, Ni, Zr, Pd, Pt or Zn.
4. The dye stabilizer of Claim 3 wherein said metal ion is Ni.

5. The dye stabilizer of Claim 1 wherein  $R_f$  is prepared from one or more types of the fluorinated monomers selected from a group consisting of epoxide, hydrofuran, cyclolactone, cyclolactam, acrylate, methacrylate and vinyl.

6. The dye stabilizer of Claim 1 wherein  $R_f$  is:



wherein the open substituent positions (not designated) on the main chain of  $R_f$  can be the same or different and may independently be selected from a group consisting of hydrogen, halogen (especially fluoro), alkyl, aryl, alkylaryl, fluoroalkyl, fluoroaryl, fluoroalkylaryl, -OR<sup>11</sup>, OCOR<sup>11</sup>, -COOR<sup>11</sup>, -CONR<sup>11</sup>R<sup>12</sup> (wherein R<sup>11</sup> and R<sup>12</sup> are independently hydrogen, alkyl, aryl, alkylaryl, fluoroalkyl, fluoroaryl, fluoroalkylaryl or fluorinated polyether) and substituted derivatives thereof;

$Z_1$ ,  $Z_2$ , and  $Z_3$  are independently oxygen or absent;

$\alpha$ ,  $\beta$  and  $\gamma$  are the weight fractions of the corresponding repeating units and are independently in the range of 0-1 with their sum no greater than 1.

7. The dye stabilizer of Claim 1 wherein one of R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, R<sup>4</sup> and R<sup>5</sup> is R<sub>f</sub>-A- and the remaining four are independently hydrogen or alkyl.

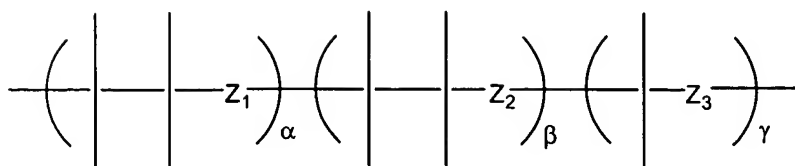
8. The dye stabilizer of Claim 7 wherein one of R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup> and R<sup>4</sup> is R<sub>f</sub>-A-, R<sup>5</sup> is alkyl and the remaining three are all hydrogen.

9. The dye stabilizer of Claim 8 wherein R<sup>5</sup> is methyl.

10. The dye stabilizer of Claim 7 wherein A in R<sub>f</sub>-A- is oxygen or absent and R<sub>f</sub> is a completely or partially fluorinated alkyl of 6 to 20 carbon atoms.

11. The dye stabilizer of Claim 6 wherein A in R<sub>f</sub>-A- is oxygen or an alkylene chain and R<sub>f</sub> is a fluorinated polymeric or oligomeric chain.

12. The dye stabilizer of Claim 11 wherein R<sub>f</sub> is:



wherein the open substituent positions (not designated) on the main chain of  $R_f$  can be the same or different and may independently be selected from a group consisting of hydrogen, halogen (especially fluoro), alkyl, aryl, alkylaryl, fluoroalkyl, fluoroaryl, fluoroalkylaryl, -OR<sup>11</sup>, OCOR<sup>11</sup>, -COOR<sup>11</sup>, -CONR<sup>11</sup>R<sup>12</sup> (wherein R<sup>11</sup> and R<sup>12</sup> are independently hydrogen, alkyl, aryl, alkylaryl, fluoroalkyl, fluoroaryl, fluoroalkylaryl or fluorinated polyether) and substituted derivatives thereof;

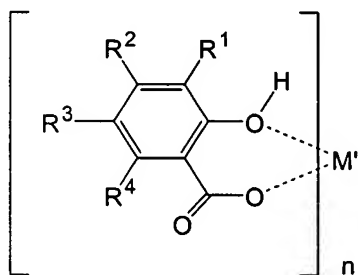
Z<sub>1</sub>, Z<sub>2</sub>, and Z<sub>3</sub> are independently oxygen or absent;

$\alpha$ ,  $\beta$  and  $\gamma$  are the weight fractions of the corresponding repeating units and are independently in the range of 0-1 with their sum no greater than 1.

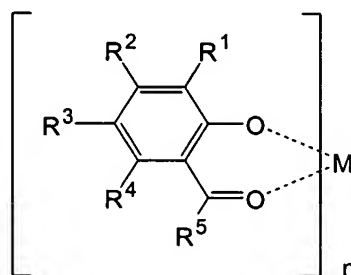
13. The dye stabilizer of Claim 12 wherein the open substituent positions are independently hydrogen, fluorine or fluorinated alkyl.

14. The dye stabilizer of Claim 11 wherein said fluorinated polymeric or oligomeric chain is a fluorinated polyether.

15. A dye stabilizer represented by Formula 2 or 3:



Formula 2



Formula 3

wherein:

M' is absent or a metal ion;

n is 2 or 3;

$R^1$ ,  $R^2$ ,  $R^3$ ,  $R^4$  and  $R^5$  are independently,  $R_f$ -A- (wherein  $R_f$  and A are defined below), hydrogen, hydroxyl, halogen, nitro, cyano, alkyl, heteroalkyl, aryl, heteroaryl, alkylaryl, arylalkyl, alkyl-heteroaryl, heteroalkylaryl, aryl-heteroalkyl, heteroarylalkyl, alkoxy, aryloxy, benzoyl, acetyl, carbonyl, sulfonyl, amido, carbamoyl, sulfonamido, sulfamoyl or heterocyclyl, or any two of  $R^1$ ,  $R^2$ ,  $R^3$  or  $R^4$  in Formula 2 or any two of  $R^1$ ,  $R^2$ ,  $R^3$ ,  $R^4$  or  $R^5$  in Formula 3 together may form a cycloalkyl or heterocyclic group, provided that at least one of  $R^1$ ,  $R^2$ ,  $R^3$  and  $R^4$  in Formula 2 and at least one of  $R^1$ ,  $R^2$ ,  $R^3$ ,  $R^4$  and  $R^5$  in Formula 3 is  $R_f$ -A-;

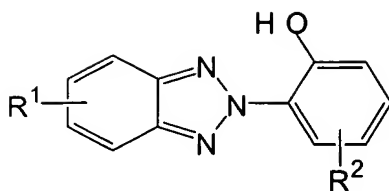
A in  $R_f$ -A- is absent, oxygen or an alkylene chain; and

$R_f$  is a fluorinated alkyl or aryl or a low/medium molecular weight fluorinated polymeric or oligomeric moiety.

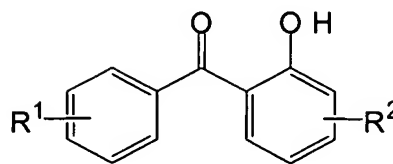
16. The dye stabilizer of Claim 15 wherein said metal ion is Ni, Co, Cu, Fe, Mn, Zr, Pd, Pt, Mg, Al or Zn.

17. The dye stabilizer of Claim 15 wherein  $R_f$  is prepared from one or more types of the fluorinated monomers selected from a group consisting of epoxide, hydrofuran, cyclolactone, cyclolactam, acrylate, methacrylate and vinyl.

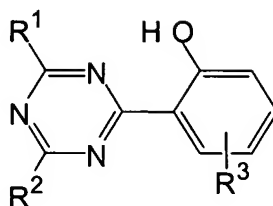
18. A dye stabilizer represented by Formula 4, 5 or 6:



Formula 4



Formula 5



Formula 6

wherein:

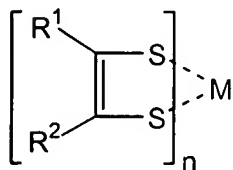
R<sup>1</sup>, R<sup>2</sup> and R<sup>3</sup> are independently, R<sub>F</sub>-A- (wherein R<sub>F</sub> and A are defined below), hydrogen, hydroxyl, halogen, nitro, cyano, alkyl, heteroalkyl, aryl, heteroaryl, alkylaryl, arylalkyl, alkyl-heteroaryl, heteroalkylaryl, aryl-heteroalkyl, heteroarylalkyl, alkoxy, aryloxy, benzoyl, acetyl, carbonyl, sulfonyl, amido, carbamoyl, sulfonamido, sulfamoyl or heterocyclyl, provided at least one of R<sup>1</sup> and R<sup>2</sup> in Formula 4 or 5 and at least one of R<sup>1</sup>, R<sup>2</sup> and R<sup>3</sup> in Formula 6 is R<sub>F</sub>-A-;

A in R<sub>F</sub>-A- is absent, oxygen or an alkylene chain; and

R<sub>F</sub> is a fluorinated alkyl or aryl or a low/medium molecular weight fluorinated polymeric or oligomeric moiety.

19. The dye stabilizer of Claim 18 wherein R<sub>F</sub> is prepared from one or more types of the fluorinated monomers selected from a group consisting of epoxide, hydrofuran, cyclolactone, cyclolactam, acrylate, methacrylate and vinyl.

20. A dye stabilizer represented by Formula 7:



Formula 7

wherein:

M is a metal ion;

n is 2 or 3;

R<sup>1</sup> and R<sup>2</sup> are independently, R<sub>F</sub>-A- (wherein R<sub>F</sub> and A are defined below), hydrogen, hydroxyl, halogen, nitro, cyano, alkyl, heteroalkyl, aryl, heteroaryl, alkylaryl, arylalkyl, alkyl-heteroaryl, heteroalkylaryl, aryl-heteroalkyl, heteroarylalkyl, alkoxy, aryloxy, benzoyl, acetyl, carbonyl, sulfonyl, amido, carbamoyl, sulfonamido, sulfamoyl or heterocyclyl, provided at least one of R<sup>1</sup> and R<sup>2</sup> is R<sub>F</sub>-A-;

A in R<sub>F</sub>-A- is absent, oxygen or an alkylene chain; and

R<sub>F</sub> is a fluorinated alkyl or aryl or a low/medium molecular weight fluorinated polymeric or oligomeric moiety.

21. The dye stabilizer of Claim 20 wherein M is Co, Cu, Fe, Mn, Ni, Zr, Pd, Pt or Zn.

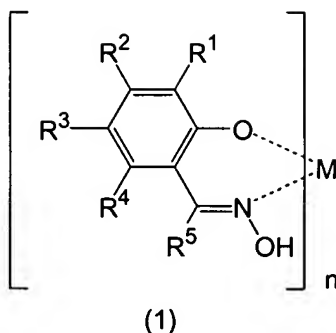
22. The dye stabilizer of Claim 1, 15, 18 or 20 wherein A in R<sub>F</sub>-A- is absent and R<sub>F</sub> is a completely or partially fluorinated alkyl of 6-20 carbon atoms.

23. The dye stabilizer of Claim 1, 15, 18 or 20 wherein R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, R<sup>4</sup> and R<sup>5</sup> in Formulas 1 and 3, R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup> and R<sup>4</sup> in Formula 2, R<sup>1</sup> and R<sup>2</sup> in Formulas 4, 5 and 7 and R<sup>1</sup>, R<sup>2</sup> and R<sup>3</sup> in Formula 6 are so selected that the total fluorine content of the dye stabilizer molecule is at least 10% by weight of the molecule.

24. The dye stabilizer of Claim 23 wherein the total fluorine content of the dye stabilizer molecule is at least 20 % by weight of the molecule.

25. The dye stabilizer of Claim 24 wherein the total fluorine content of the dye stabilizer molecule is at least 50 % by weight of the molecule.

26. An electrophoretic fluid comprising charged pigment particles dispersed in a dielectric solvent or solvent mixture, a dye or dye mixture and a dye stabilizer represented by Formula 1:



M is a metal ion;

n is 2 or 3;

$R^1$ ,  $R^2$ ,  $R^3$ ,  $R^4$  and  $R^5$  are, independently,  $R_f$ -A- (wherein  $R_f$  and A are defined below), hydrogen, hydroxyl, halogen, nitro, cyano, alkyl, heteroalkyl, aryl, heteroaryl, alkylaryl, arylalkyl, alkyl-heteroaryl, heteroalkylaryl, aryl-heteroalkyl, heteroarylalkyl, alkoxy, aryloxy, benzoyl, acetyl, carbonyl, sulfonyl, amido, carbamoyl, sulfonamido, sulfamoyl or heterocyclyl, or any two of  $R^1$ ,  $R^2$ ,  $R^3$ ,  $R^4$  or  $R^5$  together may form a cycloalkyl or heterocyclic group, provided that at least one of  $R^1$ ,  $R^2$ ,  $R^3$ ,  $R^4$  and  $R^5$  is  $R_f$ -A-;

A in  $R_f$ -A- is absent, oxygen or an alkylene chain; and

$R_f$  is a fluorinated alkyl or aryl or a low/medium molecular weight fluorinated polymeric or oligomeric moiety.

27. The electrophoretic fluid of Claim 26 wherein said metal ion is Co, Cu, Fe, Mn, Ni, Zr, Pd, Pt or Zn.

28. The electrophoretic fluid of Claim 27 wherein said metal ion is Ni.

29. The electrophoretic fluid of Claim 26 wherein  $R_f$  is prepared from one or more types of the fluorinated monomers selected from a group consisting of epoxide, hydrofuran, cyclolactone, cyclolactam, acrylate, methacrylate and vinyl.

30. The electrophoretic fluid of Claim 26 wherein one of  $R^1$ ,  $R^2$ ,  $R^3$  and  $R^4$  and  $R^5$  is  $R_f$ -A- and the remaining four are independently hydrogen or alkyl.

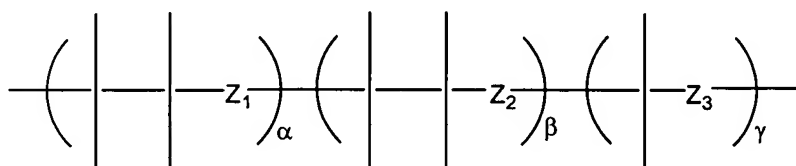
31. The electrophoretic fluid of Claim 30 wherein one of  $R^1$ ,  $R^2$ ,  $R^3$  and  $R^4$  is  $R_f$ -A-,  $R^5$  is alkyl and the remaining three are all hydrogen.

32. The electrophoretic fluid of Claim 31 wherein R<sup>5</sup> is methyl.

33. The electrophoretic fluid of Claim 30 wherein A in R<sub>f</sub>-A- is oxygen or absent and R<sub>f</sub> is a completely or partially fluorinated alkyl of 6 to 20 carbon atoms.

34. The electrophoretic fluid of Claim 30 wherein A in R<sub>f</sub>-A- is oxygen or an alkylene chain and R<sub>f</sub> is a fluorinated polymeric or oligomeric chain.

35. The electrophoretic fluid of Claim 34 wherein R<sub>f</sub> is:



wherein the open substituent positions (not designated) on the main chain of R<sub>f</sub> can be the same or different and may independently be selected from a group consisting of hydrogen, halogen (especially fluoro), alkyl, aryl, alkylaryl, fluoroalkyl, fluoroaryl, fluoroalkylaryl, -OR<sup>11</sup>, OCOR<sup>11</sup>, -COOR<sup>11</sup>, -CONR<sup>11</sup>R<sup>12</sup> (wherein R<sup>11</sup> and R<sup>12</sup> are independently hydrogen, alkyl, aryl, alkylaryl, fluoroalkyl, fluoroaryl, fluoroalkylaryl or fluorinated polyether) and substituted derivatives thereof;

Z<sub>1</sub>, Z<sub>2</sub>, and Z<sub>3</sub> are independently oxygen or absent;

α, β and γ are the weight fractions of the corresponding repeating units and are independently in the range of 0-1 with their sum no greater than 1.

36. The electrophoretic fluid of Claim 35 wherein the open substituent positions are independently hydrogen, fluorine or fluorinated alkyl.

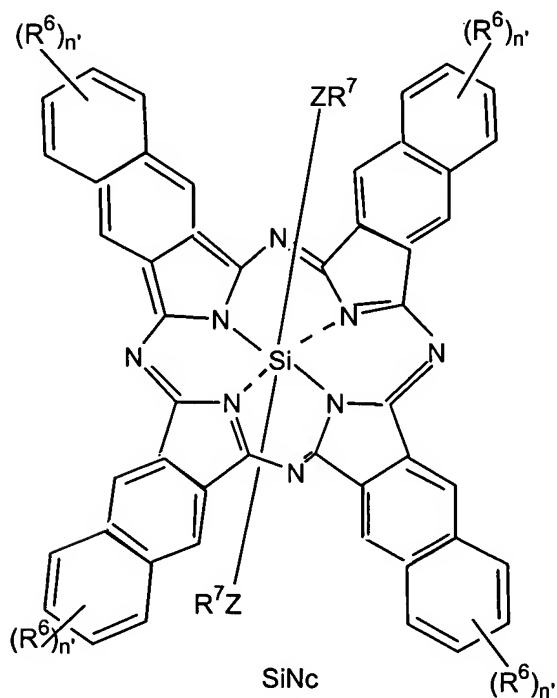
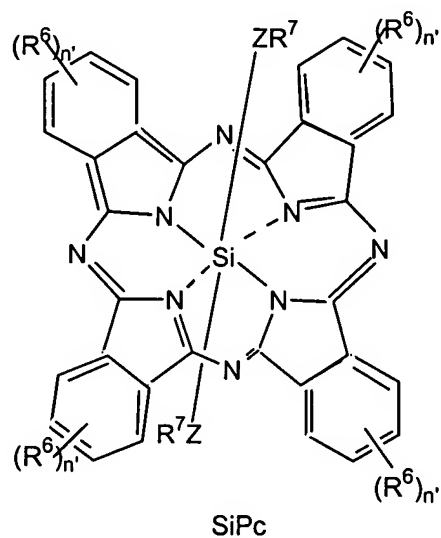
37. The electrophoretic fluid of Claim 34 wherein said fluorinated polymeric or oligomeric chain is fluorinated polyether.

38. The electrophoretic fluid of Claim 30 wherein A in R<sub>f</sub>-A- is absent and R<sub>f</sub> is a completely or partially fluorinated alkyl of 6-20 carbon atoms.

39. The electrophoretic fluid of Claim 26 wherein said colorant is a Si phthalocyanine or naphthalocyanine dye.



40. The electrophoretic fluid of Claim 39 wherein said Si phthalocyanine or naphthalocyanine dye is represented by the following formulas:



wherein:

$n'$  is 0-4 for silicon phthalocyanine (SiPc) or 0-6 for silicon naphthalocyanine (SiNc);

$R^6$  is independently  $R_f-X$  (wherein  $R_f$  is as defined below and  $X$  is a single bond,  $-CH_2O-$ ,  $-CH_2CH_2O-$  or  $-CO-$ ), alkyl, heteroalkyl, aryl, heteroaryl, alkylaryl, arylalkyl, heteroalkylaryl, alkyl-heteroaryl, heteroarylalkyl, aryl-heteroalkyl,  $R'O-$ ,  $R'S-$ ,  $R'R''N-$ ,  $R'CO-$ ,  $R'OCO-$ ,  $R'COO-$ ,  $R'CONR''-$ ,  $R'R''NCO-$ ,  $R'NHCONR''-$ ,  $R'SO_2NR''-$ ,  $R'R''NSO_2-$  or halogenated, particularly fluorinated, derivative thereof in which  $R'$  and  $R''$  are independently hydrogen,  $R_f$  (as defined below), alkyl, heteroalkyl, aryl, heteroaryl, alkylaryl, arylalkyl, heteroalkylaryl, alkyl-heteroaryl, heteroarylalkyl, aryl-heteroalkyl;

$Z$  is  $O$  or  $NR'$  wherein  $R'$  is defined as above;

$R^7$  is hydrogen,  $R_f-Y$  (wherein  $R_f$  is as defined below and  $Y$  is a single bond,  $-CH_2-$  or  $-CH_2CH_2-$ ), alkyl, heteroalkyl or halogenated, particularly fluorinated derivatives thereof, or  $-SiR^8R^9R^{10}$  wherein  $R^8$ ,  $R^9$ , and  $R^{10}$  are independently an alkyl or fluoroalkyl group of 1 to 20 carbon atoms or alkoxy or fluoroalkoxy of 2 to 40 carbon atoms; and  $R_f$  is a fluorinated polymeric or oligomeric chain (M.W.=100-100,000).

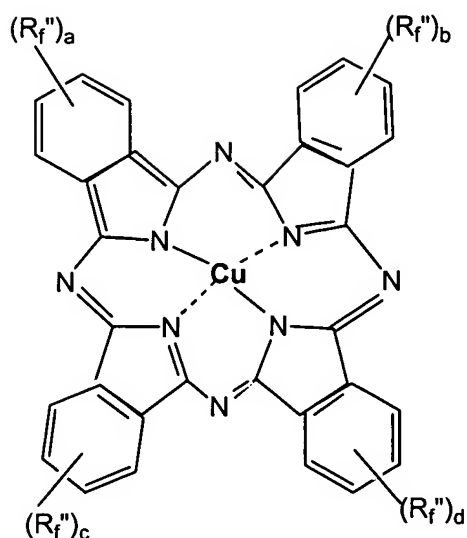
41. The electrophoretic fluid of Claim 40 wherein the substituents,  $R^6$ ,  $R^7$ ,  $R^8$ ,  $R^9$ ,  $R^{10}$ ,  $R_f$ , and  $n'$  are so selected that the total fluorine content of the silicon phthalocyanine dye is at least 20% by weight of the dye molecule.

42. The electrophoretic fluid of Claim 41 wherein the substituents,  $R^6$ ,  $R^7$ ,  $R^8$ ,  $R^9$ ,  $R^{10}$ ,  $R_f$ , and  $n'$  are so selected that the total fluorine content of the silicon phthalocyanine dye is at least 30% by weight of the dye molecule.

43. The electrophoretic fluid of Claim 42 wherein the substituents,  $R^6$ ,  $R^7$ ,  $R^8$ ,  $R^9$ ,  $R^{10}$ ,  $R_f$ , and  $n'$  are so selected that the total fluorine content of the silicon phthalocyanine dye is at least 50% by weight of the dye molecule.

44. The electrophoretic display of Claim 26 wherein said colorant mixture comprises a Si phthalocyanine or naphthalocyanine dye and a Cu phthalocyanine dye.

45. The electrophoretic display of Claim 44 wherein said Cu phthalocyanine dye is represented by the following formula:



CuPc

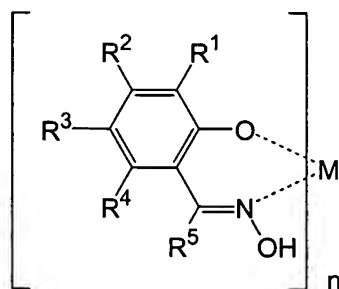
wherein  $R_f''$  is  $C_nH_xF_{2n+1-x}$  in which  $n$  is 1-18,  $x$  is 0-37,  $a$ ,  $b$ ,  $c$  and  $d$  are independently 0-4 provided that  $a+b+c+d \geq 3$ .

46. The electrophoretic fluid of Claim 45 wherein  $n$  is 4-12.
47. The electrophoretic fluid of Claim 44 wherein the ratio of the Si phthalocyanine or naphthalocyanine dye to the Cu phthalocyanine dye is 1/10 to 10/1.
48. The electrophoretic fluid of Claim 47 wherein the ratio of the Si phthalocyanine or naphthalocyanine dye to the Cu phthalocyanine dye is 1/5 to 5/1.
49. The electrophoretic fluid of Claim 48 wherein the ratio of the Si phthalocyanine or naphthalocyanine dye to the Cu phthalocyanine dye is 1/3 to 3/1.
50. The electrophoretic fluid of Claim 26 wherein said dielectric solvent is a halogenated solvent.
51. The electrophoretic fluid of Claim 50 wherein said solvent is a fluorinated solvent.
52. The electrophoretic fluid of Claim 51 wherein said fluorinated solvent is selected from a group consisting of perfluoroalkanes, perfluorocycloalkanes,

perfluoroarylalkanes, perfluoro-tert-amines, perfluoropolyethers, hydrofluoropolyethers and poly(chlorotrifluoroethylene).

53. The electrophoretic fluid of Claim 52 wherein said perfluoropolyether and hydrofluoropolyether are selected from a group consisting of Solvay Solexis HT-170, HT-200, HT-230, ZT-180 and Dupont trifluoro(trifluoromethyl)-oxirane homopolymers K-6 and K-7 fluids.

54. An electrophoretic display comprising display cells filled with a display composition which comprises pigment particles dispersed in a dielectric solvent, a dye or dye mixture and a dye stabilizer represented by the following formula:



(1)

wherein:

M is a metal ion;

n is 2 or 3;

R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, R<sup>4</sup> and R<sup>5</sup> are, independently, R<sub>f</sub>-A- (wherein R<sub>f</sub> and A are defined below), hydrogen, hydroxyl, halogen, nitro, cyano, alkyl, heteroalkyl, aryl, heteroaryl, alkylaryl, arylalkyl, alkyl-heteroaryl, heteroalkylaryl, aryl-heteroalkyl, heteroarylalkyl, alkoxy, aryloxy, benzoyl, acetyl, carbonyl, sulfonyl, amido, carbamoyl, sulfonamido, sulfamoyl or heterocyclyl, or any two of R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, R<sup>4</sup> or R<sup>5</sup> together may form a cycloalkyl or heterocyclic group, provided that at least one of R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, R<sup>4</sup> and R<sup>5</sup> is R<sub>f</sub>-A-;

A in R<sub>f</sub>-A- is absent, oxygen or an alkylene chain; and

R<sub>f</sub> is a fluorinated alkyl or aryl or a low/medium molecular weight fluorinated polymeric or oligomeric moiety.

55. The display of Claim 54 which is prepared by the Microcup® technology.

56. The display of Claim 54 which is prepared by a microencapsulation process.

57. An electrophoretic fluid comprising charged pigment particles dispersed in a dielectric solvent or solvent mixture, a colorant or colorant mixture and a dye stabilizer of Claim 15, 18 or 20.

58. An electrophoretic display comprising display cells filled with a display composition which comprises pigment particles dispersed in a dielectric solvent, a dye or dye mixture and a dye stabilizer of Claim 15, 18 or 20.